Request for Economic Stimulus Funds

Concept Proposal

Submitters (Name of Workgroup & Chair/Co-Chairs):

Murray State University, Evolvable Systems Laboratory, Dr. James Hereford (chair)

Project Title:

Array of small satellites for environment monitoring

Project Partners (Known or Anticipated):

Murray State University, Mid-America Remote Sensing Center

Kentucky Science and Technology Corporation

University of Kentucky, Intelligent Dependable Embedded Architectures (IDEA) Laboratory

Morehead State University, Space Science Laboratory

Project Background & Purpose (Justification for Project):

Small satellites, sometimes called nano-satellites, such as CubeSats have many attractive characteristics. They are small (size is 10 cm x 10 cm x 10 cm), cheap to develop and build, cheap to launch (thousands of dollars instead of millions of dollars), employ space-ground communications, and have been successfully launched many times. They are launched via

special mechanism called a Pico-Satellite Orbital Deployer (P-POD) that launches several satellites simultaneously and are usually part of a secondary payload on orbital launches.

Single nano-satellites have limited capabilities relative to larger satellites. The main drawbacks are the limited sensing capabilities and the limited on-board processing power. To overcome those limitations, we propose using an array of nano-satellites to do atmospheric monitoring. Using an array of satellites would have the following advantages over a single large, traditional, expensive satellite:

- Larger spatial coverage – the nano-sats would be deployed so that there were spatially separated. In this way, they could form either (a) a large phased array antenna or (b) as individual sampling points within the atmosphere.
- Simpler ground communication – since the nano-sats are spatially distinct, they would not be within communication range of the ground station at the same time. Thus, the ground station would only need to talk with one nano-sat at a time.
- Phased launch cycle – nano-sats would be deployed in phases, thus reducing cost.
- Repeatable design – each nano-sat would be identical, thus reducing development, programming, and testing time.
- Reconfigurability – as mentioned above the nano-sats could be re-positioned and/or re-programmed to function together as single phased-array antenna with a long baseline.
- Fault tolerance – if one or more of the nano-sats is damaged or lost, then the other functional nano-sats can continue to take measurements and provide environmental monitoring.

The result will be a system that is cheap relative to using large satellites, versatile, reconfigurable, fault tolerant, and scalable to large numbers.

Project Description (General Goals & Implementation Strategies):

We will use an array of nano-satellites for atmospheric monitoring. The nano-sats will communicate with a ground station that will compile the information and provide detailed mapping of the nano-sat measurements. This will provide high spatial resolution data for analysis.

Because of the difficulty in scheduling satellite launches, we will build and launch only 3 nano-sats using 1 P-POD during this initial phase. (Follow-on funding will be solicited to launch more

nano-sats.) The work will be broken down into four main areas: (i) design and build of the nano-sats; (ii) Geographic Information System (GIS) development; (iii) algorithm development; (iv) ground station development.

Each nano-sat will be based on current CubeSat designs. For this project, the design will be customized so that each nano-sat has at least two sensors, can be spin-stabilized and "pointed" while in orbit, and has an adjustable altitude. The GIS system will receive the raw data from the nano-sats (via the ground station link) and "stitch" the data into a 3D map. Algorithm development will focus on the system-level software. This software will include modeling the overall system plus software to coordinate and synchronize the nano-sats. The ground station will communicate with each nano-sat during flyover through an RF link.

The final product will be a constellation of 3 nano-sats that will be extensible so that more nano-sats can be added. The initial system will also include a fully-developed ground station that communicates with the nano-sats, a GIS system, and algorithms to coordinate the actions of the nano-sats and the data analysis.

Project Team (Project Manager(s), Content Experts, Instructional Designers, etc.):

Dr. James Hereford (PI) – Algorithm development

Dr. Haluk Cetin – Remote Sensing, data handling, and Geographic Information Systems

Dr. Jim Lumpp – Manufacturing, system integration

Dr. Ben Malphrus – Ground station

Plus, students and technicians to support the content experts.

Project Budget & Amount of Economic Stimulus Funds Requested:

	Year 1	Year 2
Faculty salary support:	$ 65,000	$ 65,000
Summer support for 4 faculty		
Undergraduate and graduate student support:	$ 80,000	$ 80,000
3 graduate students + 2 undergraduate students		
Research engineers:	$ 90,000	$ 93,000
A BS engineer or physicist to coordinate assembly and test of nano-sats		
Half-time technician for ground station set-up and maintenance		
Nano-sat development and build (+launch):	$ 90,000	$100,000
Laboratory equipment + travel:	$ 30,000	$ 20,000
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Total	$355,000	$358,000
Overhead		
30% overhead	$106,500	$107,400
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Total	$461,500	$465,400

Total funds requested = $926,900